ENCLOSURE 2

DRAFT Appendix C – Partitioning Plant-Wide LOCA Frequency

Cautions, Limitations, and Definitions:

- This appendix refers to the RG 1.174 risk acceptance guidelines in terms of core damage frequency (CDF). It is understood that the large early release frequency (LERF) guidelines must also be met.
- In the context of this appendix, a "critical" break location is one that can produce and transport sufficient debris to cause core damage (e.g., by blocking the ECCS strainer).
- The examples in this appendix involve piping components. LOCA contribution from non-piping components must also be considered if these breaks in these locations can generate and transport debris.
- Methods 1 and 2 may be used for both piping and non-piping components.

Methodology

When determining the risk attributable to debris, it may be necessary to partition the plant-wide LOCA frequency so that it may be allocated to individual break locations. This may be done using one of the following methods:

1. Bounding Approach

   Analysts should identify the critical break location with the smallest diameter, D_{min}. Assuming that all breaks of this size or larger lead to core damage (even those that are non-critical) provides a bounding estimate of the risk attributable to debris (i.e., ΔCDF). Expressed mathematically:

   $$\Delta CDF = f(\text{LOCA } X \geq D_{min})$$

   If this method yields a ΔCDF that meets the risk acceptance guidelines, then the risk attributable to debris has been shown to be acceptable. Because this is meant to be an upper bound estimate of risk, the mean LOCA frequency values using arithmetic mean (AM) aggregation should be used (NUREG-1829, Table 7.13). Semi-log interpolation of the NUREG-1829 LOCA frequencies is acceptable.

   For example, consider a plant where the smallest critical break location has an effective break diameter of 8 inches. Using semi-log interpolation and AM aggregation, the analyst would calculate an exceedance frequency of f(LOCA X ≥ 8 inches) = 7.7×10^{-6} per year.

   If the bounding approach produces results that exceed the risk acceptance guidelines, the analyst should move to step 2.

2. Conservative Partitioning Approach

   If the bounding approach fails to demonstrate that the risk acceptance guidelines are met, a conservative partitioning approach may be applied. Because the uncertainty associated with assumptions regarding leaks smaller than a full break may substantially affect the results for cases where smallest critical break is only a few inches, the conservative approach is applicable to cases with smallest critical break of at lease several inches. This approach defines intervals based on

inner diameter of pipes and size of components using the criteria explained later and assigns 100% of the LOCA frequency estimated for any interval if a critical weld exists in that interval. Explained in another way, if there is even one critical weld in an interval, the entire interval is assigned a conditional core damage probability (CCDP) of 1.0. Therefore, for an interval, I_N, with one or more critical welds:

$$\Delta CDF(I_N) = f(I_N)$$

Where $f(I_N)$ = frequency of the LOCA interval N

Intervals with no critical break locations are assigned a ΔCDF of zero because regardless of how the frequency would be allocated, no breaks in these intervals are expected to lead to core damage (because all locations have CCDP = 0).

The total (plant-wide) ΔCDF is the sum of the ΔCDFs for each interval.

The intervals are chosen so that each interval is at least one-inch wide and it contains at least 10% of the bounding frequency calculated by Method 1. Adjacent intervals enclosing a frequency less than 10% of the bounding frequency should be concatenated until the full interval frequency exceeds 10%. Alternatively, if the intervals are not expanded to exceed the target 10%, the frequency of the interval with a frequency less than 10% of the bounding frequency should be rounded to be exactly 10% of the bounding frequency.

For example, consider the following set of break locations:

Table 1

Pipe ID (inner diameter - index)	Critical?	CCDP	Frequency of interval (per year)	Ratio of interval frequency to bounding frequency	Frequency for this LOCA interval, (per year)
8-1	N	0	1.37E-06	17.7%	*1.37E-06 Interval 1: [8",9"]*
8-2	Y	1			
8-3	N	0			
11-1	N	0	2.05E-06	26.6%	*2.05E-06 Interval 2: (9",11"]*
11-2	N	0			
11-3	N	0			
11-4	N	0			
12-1	N	0	7.63E-07	9.9%	*7.7E-07* Interval 3: (11",12"]*
12-2	Y	1			
12-3	Y	1			
27-1	N	0	1.87E-06	24.2%	*1.87E-06 Interval 4: (12",27"]*
27-2	Y	1			
27-3	N	0			
27-4	N	0			

31-1	Y	1	1.67E-06	21.6%	*1.67E-06 Interval 5 (larger than 27")*
31-2	Y	1			
31-3	Y	1			
* Frequency rounded to be exactly 10% of the bounding frequency computed using the first method					

The frequency for each interval has been determined using the approach described in C.2 of the RG.

In this example, an 8-inch break is, again (as in the Bounding Approach example), the smallest critical break location; however, rather than assuming that the ΔCDF is the frequency of all breaks 8 inches or larger, each frequency interval is considered separately. Any interval containing a critical weld is assigned a CCDP of 1.0. Intervals with no critical welds are assigned a ΔCDF of 0.

CDF(interval 1) = 1.37×10^{-6} per year
CDF(interval 2) = 0
CDF(interval 3) = 7.7×10^{-7} per year (7.63×10^{-7} rounded to be exactly 10% of the Bounding Approach frequency)
CDF(interval 4) = 1.87×10^{-6} per year
CDF(interval 5) = 1.67×10^{-6} per year

Total ΔCDF = $1.37\times10^{-6} + 7.7\times10^{-7} + 1.87\times10^{-6} + 1.67\times10^{-6} = 5.68\times10^{-6}$ per year